Interoperability framework for components of digital library of educational resources and services

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The main scientific and technologic problems investigated in this work deal with the overall approach to creation of a flexible cost-effective e-learning content and services system (referred to as the Digital library of education resources and services, DLE) for primary and secondary education. The main topic here is a flexible architecture model of DLE components, providing learning customisation possibilities for its users. The principle of ultimate increase of the main DLE components' (i.e. learning objects) reusability is considered. A DLE model based on modular architecture, as small as possible open source reusable e-content and e-services components is presented. Standards and interoperability are the key factors in the successful introduction of such kind of DLEs, and therefore attention in the work was focussed on investigating the possible interoperability framework for creating the architecture model of DLE components. The major issues here are the standards, the reasons for their use and a clear framework. The Lithuanian DLE for primary and secondary education, based of this approach, is presented in more detail.

Introduction: the main notions

The authors consider digital libraries of educational resources and services (DLEs) to be the aggregates of digital learning resource (LR) repositories and services organized as complex information systems. The notion of LR is used here as an 'umbrella' for all kinds of the digital learning content, such as 'learning objects', 'units of learning', etc.

There is a lot of learning object' (LO) definitions coming from various sources. The following LO notion is considered here as the most suitable basic component of a flexible cost-effective personalised DLE: "LO is any digital resource that can be reused to support

learning" (Wiley, 2000). The key notion here is 'reusability'. A LR truly becomes a LO (a LR, reusable within another learning context) when it is associated with self-describing information, i.e. metadata. Metadata is used to implement LO repositories, to search for LOs in the repository, to share LOs, to import LOs into or export them from virtual learning environments, to combine them with other LOs (using them as building blocks to build lessons, courses, etc.) (Jevsikova, Kurilovas, 2006). The various approaches to LOs attempt to meet two common objectives: (1) to reduce the overall costs of LOs, and (2) to obtain better LOs.

Learning assets (LAs) are considered here as smaller pedagogically decontextualised parts (pieces) LOs can be combined of (Jevsikova, Kurilovas, 2006).

The unit of learning (UoL) itself and all its components are considered here as embedded LOs, including learning objectives, prerequisites, learners' or trainers' roles, activity assignment, information objects, communication objects, tools and questionnaire objects (Paquette, 2004).

IMS Digital Repositories Specification defines digital repositories as a collection of resources that are accessible via a network without prior knowledge of the structure of the collection. Repositories may hold actual LOs or only their metadata.

The term virtual learning environment (VLE is used here as "a single piece of software, accessed via standard Web browser, which provides an integrated online learning environment". VLEs usually include the following functions: (1) controlled access; (2) student tracking; (3) resources and materials; (4) communications; (5) links; (6) customisation (Kurilovas, 2006).

ISO 2382-01.01.47 defines interoperability as "the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units." Interoperability relies on agreements, and the more these agreements are shared the greater the interoperability.

1. Aims of the work

There are several propositions examined here: (1) ultimate increase of the main DLE components' (i.e. LOs) reusability could ensure DLE flexibility and cost-effectiveness; (2) it is possible to ensure a stable interoperable working of DLE components (within DLE and the whole system on the European level) based on an effective interoperability framework. The presented approach to the DLE model is based of the proposition that it should consist mainly of 'ultimately reusable' LOs and their metadata repositories as well as appropriate services to create, modify and manage LOs, e.g. modularised open source VLEs. The need for reusability of LOs has at least three elements: (1) *Interoperability:* LO is interoperable and can be used in different platforms; (2) *Flexibility* in terms of pedagogic situations: LO can fit into a variety of pedagogic situations; (3) *Modifiability* to suit a particular teacher's or student's needs: LO can be made more appropriate to a pedagogic situation by modifying it to suit a particular teacher's or student's needs.

The authors' approach is that ultimate LOs should be ensured by their partition into two main separate parts (LAs and UoLs) which should work independently and have clear different functions: (1) LAs are considered not to be directly interconnected with particular pedagogical activities / designs, and therefore it should be possible to reuse the same LAs

for implementing different learning designs; (2) UoLs are, conversely, considered to be LOs containing learning activities / designs reusable for different subjects and different LOs / LAs.

This approach needs an investigation of reusability and interoperability of these two separate parts of DLE within the system and DLE as a whole on the European level. The key problem here is a possible interoperability framework for creating such DLE architecture, and the major issues here should be: what standards, why, and a clear framework.

So, the main goals of the work are: (1) to create flexible cost-effective DLE architecture model; (2) to examine international interoperability standards and specifications necessary for such DLE working, and to formulate suggestions on how to revise these standards and specifications to fit the proposed DLE model requirements; (3) to examine development of the Lithuanian DLE for primary and secondary education in more detail.

2. DLE architecture

The authors' approach to the general DLE architecture is the vision of flexible cost-effective DLE based on implementation of distinct, stand-alone, modularised, as small as possible, open code e-content and services components. It has a number of technologic and socio-economic advantages in comparison with the monolithic 'closed' proprietary approach to DLE creation. Software and systems that conform to open and international standards that enjoy community support should be favoured when purchasing systems for the public sector. Modularised learning environments with clearly defined interfaces must be produced in order to ease the development of a holistic approach based upon a combination of the possibly smallest content and software components. The work proposes educational institutions to discourage any proposals for the monolithic system architecture; the adopt a distributed model made up of distinct, stand-alone components that communicate over open protocol interfaces.

The feasibility study of creation of DLE most effective from the socio-economic perspective has proven the reliability of the proposition that the flexibility and cost-effectiveness of the DLE model should be ensured by providing ultimate reusability of LOs by dividing them into two main parts (LAs and UoLs) which should work independently and have different functions. This kind of a "reusable" DLE design could be the best possible e-learning solution from the technologic, educational, organizational and socio-economic points of view. The reusability of its main components ensures the system's pedagogical and organizational flexibility as well as better financial and economic efficiency indicators such as less investment into LRs for one probable user, major financial benefit, less time to pay off, etc.

3. DLE interoperability framework

Why should we pay more attention to interoperability? As most European countries are too small to have a sustainable domestic market, interoperability issues need to be solved if there is to be a real market across Europe for digital content. Interoperability should be central in any policy framework for e-learning standards to adopt. Exchange of resources at a regional, national or European level could be extremely beneficial. To be able to exchange resources, whether data or content, at a regional, national or European level,

the applications that are used to manage and exchange these resources must implement open interoperability standards. Otherwise resources will become locked into the various applications used by different regions and communities and, as a result, exchanging these resources will be costly and difficult. Interoperability and open interoperability standards are fundamental for ensuring that content is accessible, durable and reusable. One of the main objectives with ensuring interoperability among different learning technologies is that the customer can select different vendors for different pieces of software. It is also important to recognise that interoperability is of fundamental importance not only to the content, but also to all data, including personal data, metadata, course data, legal information, etc. The use of standards can result in lower costs, increased supply and access, higher quality and shorter delivery times (Roadmap…, 2006).

Interoperability in different areas (learning content and repositories, learning activity, accessibility, assessment, and learner information) was examined, and a clear interoperability framework of a flexible cost-effective DLE model was worked out by the authors.

3.1. Reusability of learning objects

The three elements of LOs reusability, namely interoperability, flexibility in terms of pedagogic situations, and modifiability to suit a particular teacher's or student's needs, will be discussed here along with LOs reusability issues on the European level (LR exchange and LO relation with the curricula).

3.1.1 Interoperability of learning objects

Essentially, technical reusability is a synonym of technical interoperability and refers to the capacity of reading metadata as well as the way the LO repository manages technical protocols. It also involves the way the LO repository proposes storing, searching, harvesting and accessing LOs. Therefore, we may distinguish three areas where it is possible to elaborate specific quality criteria and strategies to increase reuse: (a) metadata accuracy and appropriateness; (b) technical quality of a LO itself; (3) technical quality of the LO repository.

3.1.2 The same learning objects, different pedagogy

The relationship between the internal context of the LO itself and the external context into which it is being placed determines whether or not LO "fits" that context. The less specific the internal context of the LO, the more instructional contexts it will "fit." While the primary design criterion of LOs-based approaches is generally reusability, considerations of granularity (i.e. how "big" a LO should be: an inversely proportional relationship between the size of LO and its potential for reuse) and architecture (i.e. the structure according to which LOs should be assembled) frequently requires designers to reformat all the existing content before it can be "reused" in a given LO system (Wiley, 2003). It is possible to support a constructivist or advanced pedagogy through the use of LOs, but this is more likely to be a feature of a teacher's classroom than a LO. The LO type may have some impact on this, but it is evident that even the most apparently 'non-constructivist' or 'non-advanced' LO could be used as part of advanced pedagogy, if the teachers have the skill of its use and a repertoire of approaches in their teaching (McCormick et al., 2004).

3.1.3 European learning resource exchange policy

European LR implementation in education policy is based on LR exchange (LRE). The main principles of this policy are: (1) LRs are described using an open LOM standard for expressing metadata on LRs; (2) a federated search engine to search for LRs is implemented. LRE is a service that provides the means to unlock the educational content hidden in digital repositories across Europe and share it among all partners of LRE and their users. The LRE system is implemented by connecting national LR repositories of various countries to the federation system – an infrastructure for discovering and exchanging LRs, where each partner remains in control of LRs and their metadata. Core services provided by the LRE system are: (1) LR discovery; (2) LR exchange (including DRM); (3) LR semantic interoperability. The quality of the former two services depends on implementation of the latter service – semantic interoperability of LRs.

3.1.4 TGA ontology and curricula mapping

Semantic interoperability and reusability in comprehensive curricula-based education could be ensured if we could provide mechanisms by which a meaningful entity in a country's curricula can be mapped to a meaningful entity in the other countries' curricula.

The proposed approach is an ontology covering a common set of features for LOs and curricula. This is a three-aspect classification model describing topic, goal and activity features (TGA). For curriculum analysis: (1) the "T" refers to the topic of part of the curriculum; (2) the "G" refers to the desired level or competence that learners should obtain; (3) the "A" refers to intended and prescribed learning activities by the pupils as part of the competence descriptions. To capture the semantics of curricula cross Europe, we need to classify them according to at least T, G and A. Other contextual factors to avoid ambiguity have to be presented in the LOM profile. When you browse the curriculum using the Topic Map and select a node based on the semantic tagging of that part of the document, you should get a list of "goal-oriented words" and a list of "topic-oriented words"; based on the combination of this information and the TGA classification, a set of LOs should be provided (Specifications…, 2006).

3.2. Reusability of learning activities

A lot of learning does not come from knowledge resources at all, but stems from the activities of learners solving problems, interacting with real devices, interacting in their social and work situation (Paquette, 2004). One of the basic aims of the IMS Learning Design (IMS LD, 2003) specification is to enable the abstraction of different learning design approaches into a meta-language that will represent and allow the interchange of practically any learning scenario. IMS LD can be described as an XML-based description of requirements for e-learning, based on the conceptual model of "people doing activities with resources". LD describes tasks and activities, their assignment to roles, and the flow of activities that constitute a course module or lesson known as UoL (Empirical study…, 2006). LD information model needs to be expressed in a standard XML binding enabling computer processing by any compliant VLE. UoL is basically an IMS Content Package where the organization's element (that defines the struc-

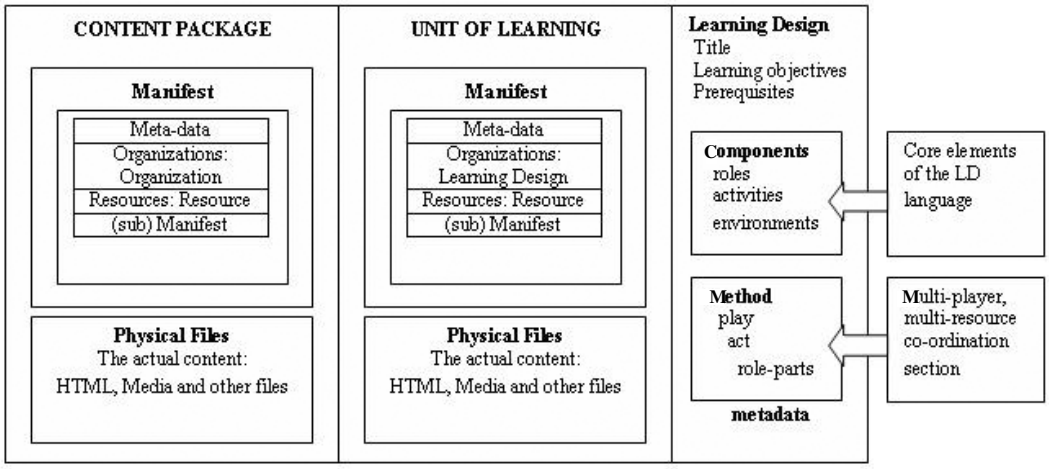

Figure 1. ***IMS LD location in IMS Content Package and structure of IMS LD elements.***

ture of the overall learning experience) is LD-specific (Figure 1).

In IMS LD, the idea has been to reuse the elements representing learning processes in different ways. Using IMS LD, it is possible both to take the existing learning design and use it with new LRs. Unfortunately, there are currently almost no environments that can take the existing learning design and run it, also there is a paucity of tools available to assist in creating a learning design. However, there are only several recent developments (tools) that are worth of mentioning here: (1) LAMS, URL: http://www.lamsfoundation.org/; (2) RELOAD project, URL: www.reload.ac.uk; (3) EduSource project, URL: www. edu-source.ca., etc.

4. Contemporary Lithuanian practice

At the moment, there are several LR repositories in Lithuania, created for primary and secondary education since 2001, which provide several keyword-based non-standardized search possibilities for users. Several important developments were carried out in 2005–2006: (1) scientific research on complex evaluation of the most popular open source VLEs was performed (Kurilovas, 2005). Several scientific methods and frameworks were used as basic tools for this research. As a result, Moodle VLE was evaluated as the best VLE suitable to use on the module level, therefore it was proposed as the most suitable VLE for a wide implementation in Lithuanian comprehensive and vocational schools, as well as for teacher in-service training system. Its fundamental advantages in comparison with the other open source systems are: (a) clear social constructivist philosophy and design; (b) modular, extensible architecture; (c) a wide and lively developer and user community (Kurilovas, 2005). In summer 2006, Moodle version 1.6.3 was fully localised and at the moment is downloadable for installation in schools; (2) the EUN LO metadata (LOM) application profile (AP) 2.0 was localised; (3) separate LO metadata (LOM) repository based on MySQL

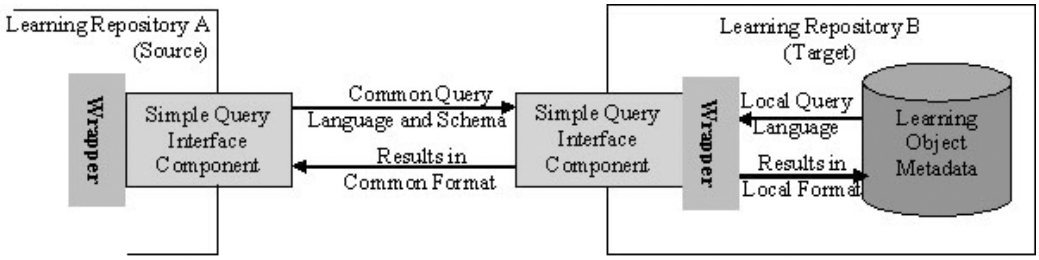

Figure 2. ***Communication between two repositories.***

database management system, PHP software package and Java technology, as well as a user-friendly interface to aggregate all LO metadata into a LOM repository were created; (4) metadata for more than 1200 Lithuanian LRs were created in conformity with LOM AP, and aggregated into the LOM repository by specially trained indexers; (5) several distance-learning courses were disaggregated to a LO level and introduced as SCORM 2004 packages to reuse in different VLEs; (6) the LOM repository was connected to the European LRE system using the Simple Query Interface technology and the Brokerage system.

5. Recommendations

5.1 The system's architecture

General System's Specification: Components and Their Interoperability:

- e-Content:

(1) LOs / LA repositories: (1a) contain approved and recommended LOs / LAs evaluated in conformity with an appropriate instrument (Kurilovas, 2007); (1b) can be physically located in different servers; (1c) all LOs fit accessibility interoperability requirements (they are horizontal for all system's components); (2) Learning Activities repositories: (2a) contain UoLs only; (2b) all UoLs meet IMS LD specification requirements;

- e-Services / tools for e-content their, modification, use / reuse, and personalisation:

(1) open source tools for UoL creation and modification: RELOAD, LAMS, EduSource, CopperCore, etc. (2) open source tools for standardised collaborative LO creation and modification, e.g., LeMill; (3) VLEs: (3a) open source; (3b) modular architecture; (3c) evaluated in conformity with an appropriate instrument (Kurilovas, 2007); (3d) meet IMS Common Cartridge and LD requirements; (4) e-Portfolio systems: (4a) fit main European vocabularies (e.g., competence taxonomy); (4b) fit IMS LIP or IEEE LTSC PAPI; (5) other services (e.g., social information: users' comments, LOs ratings, tagging, etc.);

- Central LO metadata repository:

(1) meets the LOM standard and its APs such as LRE AP v.3.0; (2) is connected to LRE; (3) use interoperable vocabularies (e.g., taxonomies); (4) fits Curriculum taxonomies and TGA tools; (5) implements digital rights management (DRM) based on usage of Creative Common Licences.

The DLE architecture model proposed by the authors is the following:

5.2 Proposals to Lithuanian LOM AP

The examination of LRE Metadata AP v3.0 has shown that it would be purposeful to revise LRE AP v3.0 in order to provide quicker and

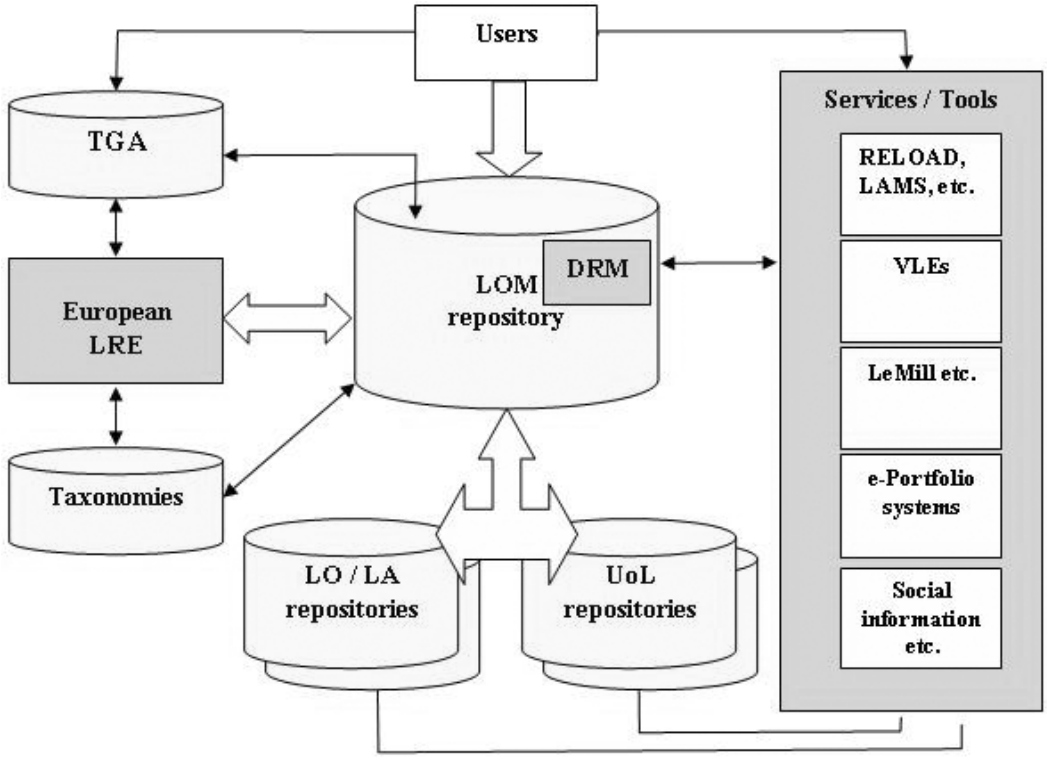

Figure 3. ***Proposed DLE architecture model.***

more convenient search possibilities for those searching for ultimately reusable e-content components by means of changing (advancing) the status of LRE AP elements listed below. This principle could be the basic one for preparation of Lithuanian LOM AP. The main LRE Metadata AP v3.0 elements whose vocabulary values could reflect the ultimate reusability of the DLE model deal with the structure of LO, its functional granularity (aggregation) level, educational type and difficulty for use as well as the kind of relation of this LO with the others. They are: (1) general: structure – 1.7. Suitable vocabulary value: Atomic: a LO that is indivisible. Assets such as individual picture, sound, etc. files are considered always 'Atomic'; (2) general: aggregation level – 1.8. Suitable vocabulary value: 1: the smallest level of aggregation; (3) educational learning resource type – 5.2. Suitable vocabulary value: learning asset: A single, multimedia asset or components that are used to create LRs including LOs. On their own, or grouped in collections, assets can be used to support learning in a wide variety of contexts. "Learning asset" is not a resource type but a category of resource types. The resource types belonging to this category are audio, data, image, model, text and video; (4) relation: Kind – 7.1. Suitable vocabulary values: ispartof, hasmetadata. Therefore the authors' recommendation while preparing the Lithuanian LOM AP is to change the status of these LRE AP elements and consider them

as: (1) mandatory elements: General. Structure – 1.7; educational. learning resource type – 5.2; (2) recommended elements: general: aggregation level – 1.8; relation: kind – 7.1.

5.3 Proposals to Lithuanian DLE for primary and secondary education

The main scientific and technologic al decisions to provide the ultimate reusability and interoperability of Lithuanian DLE content and services could be a full implementation of: (1) LO metadata interoperability standard – Lithuanian LOM AP (based on the EUN LRE Metadata AP v3.0 of the IEEE LOM standard) as well as IMS Common Cartridge (IMS Content Package AP integrating IMS Question and Test Interoperability specification and IEEE LTSC LOM standard) and IMS LD specifications; (2) repository of LD compliant UoLs and tools to create and reuse UoLs; (3) LOM repository containing LO and UoL metadata created in conformity with the newest LRE AP and taxonomies; (4) DRM system; (5) curriculum taxonomies and TGA tools.

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SKAITMENINĖS MOKYMO(SI) IŠTEKLIŲ IR PASLAUGŲ BIBLIOTEKOS SUDEDAMŲJŲ DALIŲ DAUGKARTINIO NAUDOJIMO(SI) GAIRĖS

Eugenijus Kurilovas, Svetlana Kubilinskienė

Santrauka

Šiame straipsnyje nagrinėjamos pagrindinės mokslinės ir technologinės problemos yra susijusios su bendru moksliniu požiūriu į bendrojo lavinimo sistemos el. mokymosi turinio ir paslaugų sistemos (čia – skaitmeninės švietimo išteklių ir paslaugų bibliotekos, toliau – biblioteka) kūrimą. Nagrinėjimo objektas yra lankstus bibliotekos sudedamųjų dalių architektūros modelis, suteikiantis savo naudotojams individualizuoto mokymosi galimybių. Straipsnyje yra nagrinėjamas pagrindinių bibliotekos sudedamųjų dalių (t. y. mokymosi objektų) maksimalaus pakartotinio platesnio panaudojimo principas. Straipsnyje yra pristatomas bibliotekos modelis, grindžiamas diegiamomis modulinės architektūros mažesnių atvirojo kodo el. turinio ir paslaugų sudedamosiomis dalimis. Sudedamųjų dalių sąveikumas ir standartai yra pagrindiniai bibliotekos funkcionavimo veiksniai, todėl pagrindinis dėmesys straipsnyje buvo skiriamas bibliotekos sąveikumo gairių kūrimui. Pagrindiniai klausimai yra: kurie standartai turi būti naudojami, kodėl, t. y. aiškios gairės. Detaliau nagrinėjamas Lietuvos bibliotekos bendrojo lavinimo sistemos kūrimo atvejis.

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